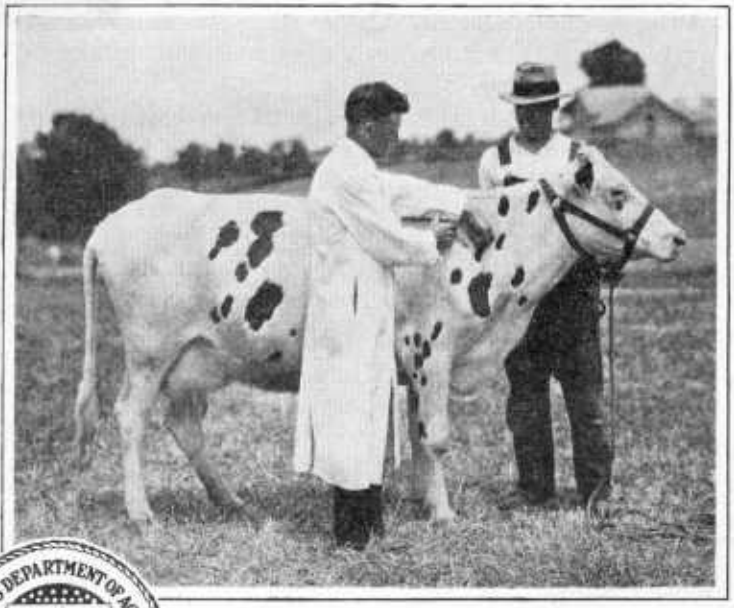
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 784

ANTHRAX

OR CHARBON



ANTHRAX, or charbon, is an acute infectious disease affecting animals and occasionally man. Cattle and sheep are most susceptible, and none of the domestic animals are exempt.

It is caused by a germ which multiplies rapidly in the body, especially in the blood, and produces poisonous substances which cause death. The germs probably are most commonly taken in with food, though they may gain entrance also through wounds. In what is known as the spore form they are very resistant to heat, cold, and disinfectants, and may survive in the soil for years.

The symptoms of anthrax vary greatly, according to the acuteness of the attack. The early stages usually are characterized by high fever, rapid pulse, and labored breathing. In the most common form of the disease there are also local external swellings or tumors. Death ensues in from a few hours to several days.

Medicinal treatment is usually of no avail in acute cases. When the progress of the disease is not too rapid, the injection of antianthrax serum will often bring about a cure.

The most effective method of dealing with anthrax is by prevention. The preventive measures recommended are (1) protecting individual animals by vaccination and (2) burning or deeply burying the carcasses of animals that have died of the disease, so as to avoid infecting the ground. Full information and directions are given in this bulletin.

This bulletin supersedes Farmers' Bulletin 439 on the same subject.

Washington, D. C.

Issued February, 1917
Revised November, 1931

ANTHRAX OR CHARBON

By HENRY J. WASHBURN, *Senior Bacteriologist, Pathological Division, Bureau of Animal Industry*[1]

CONTENTS

DESCRIPTION AND SYNONYMS

ANTHRAX, variously known as charbon, splenic fever, or splenic apoplexy, when occurring in animals, and in man as malignant pustule, malignant carbuncle, or woolsorter's disease, is an acute infectious disease caused by a germ, and as every species of domestic animal is susceptible to its attacks the disease might become one of the greatest scourges of animal life. Man is by no means immune, although fortunately the malady as it appears in the human subject is usually less acute than the form seen in cattle and sheep. This is probably because the lesions in man occur most frequently from infection of the surface of the hands or feet, while cattle and sheep are more likely to swallow the infectious germs with their feed, thus giving the germs immediate entrance into their systems, where they exert their most harmful influence without check or control.

HISTORY

Anthrax of cattle was known in southern Europe as early as 1613. It spread to the people and ultimately became a scourge, causing more than 60,000 deaths. It is evident the disease was far more virulent and inclined to attack all species of mammals during earlier times than now. During the early periods many deer and other game were destroyed.

The specific cause of anthrax, microscopic bodies in the blood, was discovered in 1850 by Davaine, the French investigator, and from this investigation has grown all that is now known of the important scientific subject of bacteriology. Later it was asserted by Koch, of Germany, that natural infection occurred through the intestinal tract, although he was unable to demonstrate it.

CAUSE OF THE DISEASE

The microscopic organism causing anthrax is known as the anthrax bacillus. In form it is cylindrical or rodlike (fig. 1),

[1] Deceased. Revised by John S. Buckley, chief of Pathological Division.

72185°—31

measuring one five-thousandth to one two-thousand-five-hundredth inch in length and one twenty-five-thousandth inch in diameter. Like all bacteria these rodlike bodies have the power of indefinite multiplication, and in the bodies of infected animals they cause death by rapidly increasing in numbers and producing substances which poison the body. In the blood they multiply in number by becoming elongated, and then dividing in two, each new organism continuing the same process indefinitely. (Fig. 2.) In the case of anthrax bacilli outside the body of the animal, under conditions unfavorable to growth, oval forms develop within the rods. (Fig. 3.) These spores remain alive but in a dormant state and are capable of germination even after years of drying. They also resist heat to a remarkable degree, so that boiling water, steam under pressure, or 285° F. of dry heat for three hours is necessary to destroy them. The bacilli themselves, on the other hand, show only very little resistance to heat and drying. This characteristic may be likened to a blade of corn, which may be destroyed very easily by the application of heat or cold, while the seed or spore will resist considerable heat and is unaffected by freezing. Spores are also very resistant to the action of disinfectants.

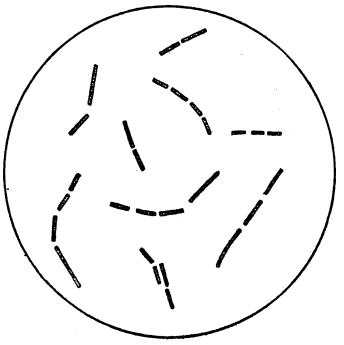


FIGURE 1.—Anthrax bacilli as they appear under the microscope. (Greatly enlarged)

The anthrax bacilli in the blood of an animal at the time of its death seldom form spores if the carcass is buried promptly, without having been opened to permit the entrance of air. In this event they are destroyed quickly; hence the advantage of the early and deep burial of all animals that die from the disease.

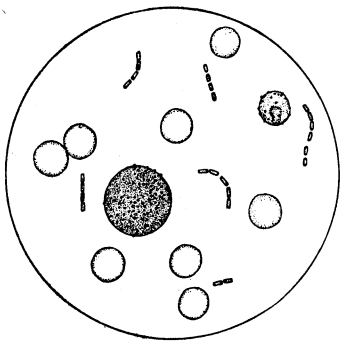


FIGURE 2.—Blood of an animal that died of anthrax. The light objects are red blood corpuscles, the shaded circular bodies are white blood cells, and the rodlike figures the anthrax bacilli. (Greatly enlarged)

It has long been known that the anthrax virus thrives best under certain conditions of the soil and in territories subject to floods and inundations. The particular kinds of soil upon which the disease is observed are black, loose, warm, humous soils, also those containing lime, marl, and clay, and finally peaty, swampy soils resting upon strata which hold water. Hence fields containing stagnant pools may be the source of infection. The infection may be limited to certain farms, or even to restricted areas on such farms. Even in the Alps at elevations of more than 3,000 feet above sea level, where such conditions prevail in secluded valleys, anthrax persists among herds.

SYMPTOMS

The symptoms of anthrax vary with the kind of animal and type of disease, except that in the last stages the most pronounced symptoms are identical. In the first or most acute of the three types (anthrax peracutus) the animal may appear at the outset to be perfectly well and keep with its fellows even when its temperature is very high—as high as 106° F. With such a temperature there is, of course, a rapid pulse and increased respiration. When one is standing close the heart beats may be plainly heard. Other symptoms are tremors, grinding of the teeth, and standing with head down; afterwards the head and ears droop and a disposition to lie down develops. Animals that have been lively will decline to rise unless handled roughly and will become stupid, sleepy, and very weak. Whereas the temperature has all along been high it now shows a sharp decline, and before death may be below the normal. The symptoms in cattle vary considerably, depending upon whether the disease begins in the skin, lungs, or intestines; they depend also on the severity of the attack. Thus in this first, or apoplectiform type, the animal dies very suddenly, as if from apoplexy. Such cases usually occur in the beginning of an outbreak. The animal, without having shown any signs of disease, suddenly drops in the pasture and dies in convulsions, or an animal apparently well at night is found dead in the morning.

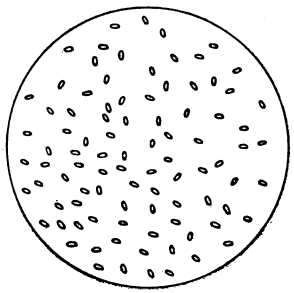


FIGURE 3.—Anthrax spores as they appear under the microscope. (Greatly enlarged)

The second type (anthrax acutus), without any external swellings, is the one principally observed in cattle. The disease begins with a high fever. The temperature may reach 106° or 107° F., with pulse beats from 80 to 100 a minute. Feeding and rumination are suspended. Chills and muscular tremors may appear and the skin show uneven temperature. The ears and base of the horns are cold, the coat staring. The animals are dull and stupid and manifest great weakness. To these symptoms others are added in the course of the disease. The dullness may give way to great uneasiness, champing of the jaws, spasms of the limbs, kicking and pawing the ground. The breathing may become labored. The nostrils then dilate, the mouth is open, the head raised, and all muscles of the chest are strained during breathing, while the visible mucous membranes (nose, mouth, rectum, and vagina) become bluish. If the disease has started in the bowels there is much pain, as shown by the moaning of the animal; the discharges, at first firm, become softer and covered with serum, mucus, and blood.

As the disease approaches the fatal termination the weakness of the animal increases. It leans against supports or lies down. Blood vessels may rupture and give rise to spots of blood on the various mucous membranes and bloody discharges from nose, mouth, rectum, and vagina. The urine not infrequently contains blood (red water). Death ensues within one or two days.

The third form of anthrax, the subacute, produces symptoms like those of the acute form except that they are of slower development. Instead of becoming established in 12 to 24 hours one to seven days may be required. The fever is very high. Serious colics are often present. Local anthrax tumors appear externally, first near the shoulders, neck, and head, and are usually caused by local injury or bruising, which gives rise to a collection of bacilli within the blood vessels of the part, thus inducing inflammation which results in the swellings or carbuncles. These tumors are at first hard and fixed, but later become cold, insensible, diffuse, and fluctuating.

An examination of the carcass of an animal dead of anthrax of the subacute form will probably show many lesions or alterations. Hemorrhages may be found in almost all parts of the body. Serous infiltrations (watery diffusions) may be present beneath mucous membranes and skin. There will be swelling of the spleen, liver, and kidneys and the blood will be of a muddy or tarry appearance and will not clot. The cavities of the body contain more or less bloody fluid, and the lymphatic glands are swollen and contain small hemorrhages. The red blood cells have broken down in large numbers and the serum of the blood has been markedly reddened. The walls of the intestines may appear perfectly normal, but hemorrhages are frequently seen, especially in the walls of the duodenum.

The subacute form is commonly met, and it is the only form which responds favorably to treatment. Death ensues so quickly in the other two forms that attempts at treatment are of but little use.

Isolated or sporadic cases are usually of the subacute form, and are frequently limited to the formation of a tumor or carbuncle at the point of the body at which the infective germs first gained their entrance.

SUSCEPTIBILITY OF VARIOUS ANIMALS

Cattle and sheep are very susceptible to infection with anthrax, and none of the domestic animals are exempt. Horses and mules contract the disease, but less readily than cattle or sheep. It is reasonable to suppose that the compound stomachs of the latter animals aid in their infection. The food passes slowly from one stomach to another, allowing time for the multiplication of any spores of anthrax that may have been swallowed with the food, until finally a dangerous number of anthrax germs are cast from the digestive tract into the blood stream, where they are in a position to cause the sudden death of the animal.

Swine are less susceptible than cattle or horses, but may contract the disease especially if allowed to eat the carcasses of animals dead from anthrax. The throat of the hog is usually the part that first shows evidence of an attack of anthrax.

Dogs and cats are still less liable to contract the disease. As with hogs, the first swellings are usually seen in the region of the throat.

Chickens are seldom affected, but if they are, the disease runs a very rapid course, producing death in 24 hours. Anthrax swellings may be seen on the comb and wattles and around the eyes.

ANTHRAX IN MAN (MALIGNANT PUSTULE, OR CARBUNCLE)

Anthrax may be transmitted to man in handling the carcasses and hides of animals which have succumbed to the disease. The infection

usually takes place through some abrasion or slight wound of the skin into which the anthrax spores, or bacilli, find their way. The point of inoculation appears at first as a dark point or patch, compared by some writers to the bite of a flea. After a few hours this is changed into a reddened pimple, which bears on its summit, usually around a hair, a yellowish blister, or vesicle, which later becomes red or bluish in color. The burning sensation in this stage is very great. Later this pimple enlarges, its center becomes dry, gangrenous, and is surrounded by an elevated discolored swelling. The center becomes drier and more leatherlike and sinks in as the whole increases in size. The skin around this swelling, or carbuncle, is stained yellow or bluish and is not infrequently swollen and doughy to the touch. The carbuncle itself rarely grows larger than a pea or a small nut and is but slightly painful.

Anthrax swellings, or edemas, may be found in man, and they are at times so extensive as to produce distortion in the appearance of the part. The color of the skin over these swellings varies according to the situation and thickness of the skin and the stage of the disease, and may be white, red, bluish, or blackish.

As these carbuncles and swellings may lead, sooner or later, to an infection of the entire body, and thus be fatal, medical assistance should at once be called if there is well-grounded suspicion that it may be a case of anthrax.

In addition to anthrax of the skin (known as malignant pustule), human beings are subject, though very rarely, to the disease of the lungs and the digestive organs. In the case of the lungs the spores are inhaled by workmen in establishments in which wool, hides, and rags are worked over, and it is therefore known as woolsorter's disease. In the case of the digestive organs the disease is contracted by eating insufficiently cooked flesh of diseased animals. These forms of the disease are more fatal than those which start from the skin.

DISTRIBUTION OF ANTHRAX

Cattle and sheep are the chief sufferers, and outbreaks are most common in animals that run upon low, moist lands of a more or less mucky character. In certain regions, where the land is mainly hilly, it has been found that anthrax appears every season among cattle in pastures containing wet, low places. When good fences are built around them, however, and the stock is kept upon the dry portions of the pasture, the disease quickly disappears. Should the fence be broken down, allowing cattle to invade the infected area at certain seasons of the year, they are very likely to contract the disease. In fact, certain plots of ground of this description have been found to retain the germs of anthrax for several years, a circumstance which has led many investigators to declare that the organism is capable of growing from year to year without any artificial aid or cultivation, if only planted upon suitable soil; that it will sprout and grow, producing the plant and later the seed, thus providing a perpetual source of infection for the stock that may be allowed on this area of growing anthrax plants.

Because of the remarkable tenacity with which certain plots of ground retained their infection, Pasteur, the eminent French authority, in 1880 reached the conclusion that the carcasses of animals dead

from anthrax, even though buried deep, retained their many infectious germs and supplied them with so much nutrient that they continued to multiply for years, and in this way produced an immense underground supply of virulent organisms. Later investigations by Kitasato, the Japanese bacteriologist, have shown that, at a depth of 18 to 20 inches below the surface of the ground, spore formation by anthrax bacilli is very incomplete and that at greater depths it must be further suppressed by the presence of the products of decomposition. Koch also has stated that earthworms are incapable of taking up anthrax spores and bringing them to the surface.

Nevertheless the fact remains that certain areas of ground remain dangerous to stock from year to year. It is still an unsettled question whether the anthrax germs grow and multiply each season upon infected lands when conditions of moisture and warmth become favorable or whether the ground becomes infected at some certain time with bacilli, developing spores which remain near the surface of the ground for years or until taken up by some susceptible animal. Careful experiments have shown that anthrax bacilli flourish and retain their virulent properties in stagnant water for at least 12 months, and certain authorities say they have observed them multiplying with no other nourishment than that afforded them by muddy water.

A consideration of some of the most seriously infected localities in this country will help to explain the conditions which tend to perpetuate the infection. Upon the rice plantations of the South, where the fields are annually submerged to favor the starting of the rice plants, many of the animals used in the cultivation of the crops contract anthrax and die as a result if driven over the infected lands after the water has subsided and a few days of hot weather have intervened.

If tanneries are built upon or near streams there is great danger that anthrax will be brought to them upon hides and then be scattered over the lowlands lying downstream. This state of affairs especially exists near those tanneries which work upon goat or sheep pelts from foreign countries. Spores adhere to these hides so persistently that ordinary fumigation fails to destroy them, and repeated outbreaks of the disease occur wherever such skins are handled.

Aside from the danger of direct inoculation to animals pasturing on infected areas, there exists the possibility of infection by means of hay or other crops that have been grown upon infected areas of land. The process of drying and curing the hay or forage does not lessen this danger, for drying favors the development of spores, which, mingling with the dust and fragments of the dried forage, may be taken up by the wind and blown about, or may cause serious damage if eaten by susceptible animals.

DIAGNOSIS

To distinguish between the apoplectic form of anthrax, cerebral hemorrhage, and sunstroke is a most difficult matter. In the less acute cases of anthrax swellings may develop and bloody urine may be noted; these indicate anthrax, although malignant edema, hemorrhagic septicemia, tick fever, and sweetclover poisoning often present symptoms that are so similar as to lead to confusion.

Distinction from blackleg may be made by noting the swellings beneath the skin which appear upon the animal. Those of blackleg are found to crackle under pressure with the finger, owing to the presence of gas within the tissues, while the tumors of anthrax, being caused by the presence of serum, are entirely free from this quality and have a somewhat doughy consistence. The tumors of blackleg usually are found on the shoulder or thigh and are not so frequent about the neck and side of the body as the swellings of anthrax. The blood of animals dead of blackleg is normal, and the spleen does not appear swollen or darkened, as in animals affected with anthrax.

The chief differences between anthrax and tick fever are that the course of the former is more acute and the blood of the animal is dark and of a tarlike consistence, while in the latter it is thinner than normal. The presence of fever ticks on the cattle also leads one to suspect tick fever in regions where cattle are not immune from the disease.

The anthrax bacillus is larger than many other forms of bacteria, and possesses a characteristic form which helps in its identification by means of microscopic examination. In order to make a definite diagnosis, however, it is quite necessary that the material to be examined reach the laboratory before degeneration has taken place. Six or eight drops of blood drawn from an animal soon after death, collected and allowed to dry on the concave side of a piece of broken glass from a fruit jar or bottle, afford the most satisfactory sample for laboratory investigation. If this manner of preparing suspected blood is not feasible the sample may be spread thinly upon a piece of window glass. In either case the samples should be allowed to dry thoroughly and then be packed in a box for mailing. Blood in bulk should not be shipped by mail or express. The container is liable to be broken in transit, in which case the scattered blood offers a serious menace to all who handle it. If shipped in a bottle it may also rapidly decompose, with the result that by the time it has reached the laboratory the anthrax bacilli have disappeared and diagnosis from that sample will be impossible. If the blood is dried upon glass before shipping, the germs within it will remain unchanged until removed for examination. Furthermore, if blood is shipped in bulk, numerous forms of bacteria which produce decay will develop before its destination is reached. The presence of these bacteria complicates the examination and their development may be responsible for a negative diagnosis in some cases where anthrax bacilli were present in the collected blood. Similar changes occur in visceral organs if shipped in cans or jars, and therefore the shipment of such material should never be attempted. A satisfactory way is to remove an ear of a suspected carcass close to the head so that sufficient blood can be obtained from the ear veins, wrap it in cheese cloth which has been dipped in a solution of corrosive sublimate prepared by mixing 1 part of corrosive sublimate with 1,000 parts of sterile water, and send it by mail or express to a laboratory for examination.

ANATOMICAL CHANGES

Early in the development of the disease hemorrhages form beneath the serous membranes of the large organs of the body. Swellings

appear in the tissues beneath the skin, which consist of a jellylike mass, yellowish in color and more or less tinged with blood. The lymphatic glands become swollen and softened. If cut, their exposed surfaces display numerous minute hemorrhages. Swellings may appear in the mouth, upon the tongue, or in the rectum. The bodies of animals that have died of anthrax soon lose their rigidity and become bloated, because decomposition sets in very rapidly. Bloodstained fluid flows in small quantities from the mouth, nose, and anus. When the carcasses are opened and examined, it will be found that nearly all the organs are sprinkled with spots of blood of various sizes. The spleen is enlarged to from 2 to 5 times its normal size, and it will be noted that its pulp is blackish, soft, and occasionally disintegrated. The blood is of a tarry consistency, will not clot firmly, and is blackish in color. The lungs are congested and distended with serum. The small intestines and stomach may show areas that are intensely red, with blackish-red blood spots. Similar areas may be present upon the walls of the abdomen. If the brain is examined it usually appears congested and spotted with blood. The hemorrhages that are present in the carcass of an animal dead of anthrax generally present an unusual appearance, caused

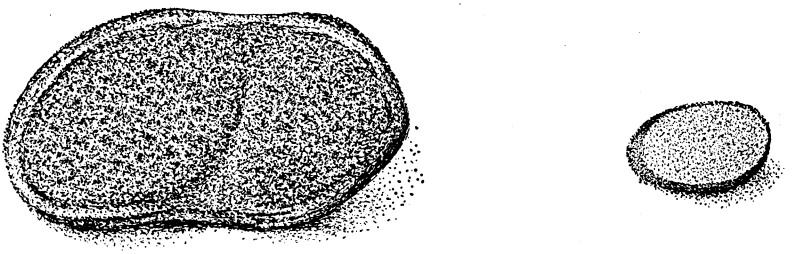


FIGURE 4.—Submaxillary gland (left) of animal affected with anthrax. Small gland at right is a submaxillary gland taken from a healthy animal

by the swollen area surrounding them, in which jellylike material collects.

In hogs the lesions are chiefly found in the region of the neck and throat. Here marked watery and bloody swelling of the tissues of the throat is in evidence. The submaxillary lymph glands located near the angles of the jawbones (fig. 4) are hard, enlarged, reddened, and frequently show necrotic changes. The tonsils are often covered by a yellowish coating, are greatly swollen and ulcerated. (Fig. 5.) The spleen from a hog's carcass usually presents a normal appearance, but it may be swollen and softened. Intestinal lesions of anthrax are rarely found in hogs.

In certain instances anthrax in one or more of the intestinal glands of swine has been observed. In these cases a fluid exudate surrounding the bloody and swollen lymph glands represented the only signs of the disease that were found in the affected animals.

In recent years the number of swine carcasses condemned for anthrax has increased, as shown by the records of Federal meat inspection. In the fiscal year ended June 30, 1930, there were 286 carcasses condemned while only 104 were found the previous year. In 1928 there were 74 and in 1927 only 13. These figures, however,

are not necessarily an index to the extent of anthrax in the country since they do not include the number of animals dying on farms.

TREATMENT

Medicinal treatment of anthrax in animals has not proved satisfactory. In cases of local anthrax, incision of the swelling followed by the application of disinfectants sometimes gives good results. In such cases, however, the danger of disseminating the infection through discharges from the wound would tend to make this inadvisable, unless great care is taken and suitable quarters are available.

As is shown later, good results have been obtained from the use of serum in the treatment of the disease. For this purpose 30 to 100 cubic centimeters should be administered beneath the skin or into a vein. If no improvement is noticed within 24 hours, the injection should be repeated. In a number of occasions afforded to test the curative value of the bureau serum on cases of anthrax in man and in animals, splendid results were obtained.

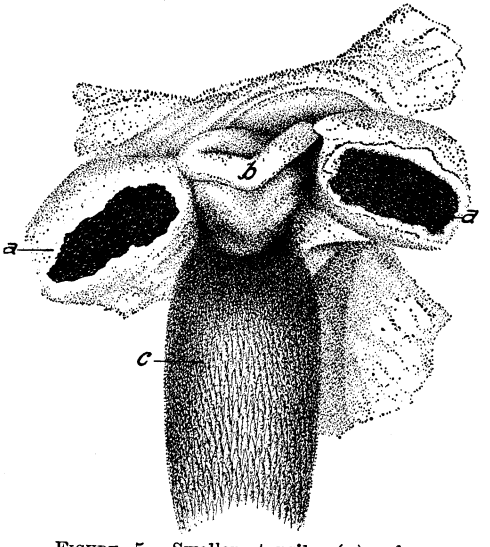


FIGURE 5.—Swollen tonsils (*a*) of a hog that died of anthrax. The other organs shown are epiglottis (*b*) and tongue (*c*)

PREVENTIVE VACCINES

In studies of some of the various infectious diseases it has been found that one of the most practical means of preventing their extension is to furnish the susceptible and exposed animals with artificial immunity. (See title-page.) This is the case with blackleg, anthrax, hog cholera, and the like. Many animals prove to be naturally immune from these diseases, while others must be made so by inoculation with suitably prepared materials. Investigators the world over have expended a vast amount of effort and study in attempts to discover and perfect the most effective and at the same time the most practicable means of making animals immune from the more destructive of the infectious diseases. Immense amounts of money, both from governmental sources and from gifts of private wealth, have been appropriated for the advancement of these researches. The goal sought by these searchers along lines of agricultural interest is the discovery of some means by which immunity may be conveyed readily to a large number of animals and at slight expense.

The successful vaccination of cattle against any of these infections strengthens the body tissues in such a way that no great number of germs can find lodgment and nurture there. After such vacci-

nation the animal is fully protected and can go with perfect safety into localities that would have been deadly before the vaccination was performed.

Just how this immunity is obtained is still an open question, but it is manifest that the immunizing agent affects the tissues (some say the animal cells, others the fluid tissues) in such manner that virulent organisms can not possibly thrive therein, and without the rapid multiplication of virulent organisms within the animal tissues there can be no infection.

PASTEUR VACCINE

Beginning with a thrifty culture of anthrax bacilli growing in a flask of bouillon, Pasteur, in 1881, by a series of experiments found that subjecting it to a temperature of 108.5° F. for 12 days would so lower the virulence of the organisms that they would only exceptionally cause death when injected into rabbits. Continuing the attenuation by subjecting the bacilli to the same degree of heat for 12 days longer, or 24 days in all, he discovered that he had in his possession a living culture of anthrax bacilli that had lost its power for killing cattle, sheep, rabbits, or guinea pigs, although still capable of killing white mice. This was the beginning of the practical preparation of anthrax vaccine, for he soon found that cattle or sheep when inoculated with the culture of 24 days' heating would survive the treatment and would gain a very material power in resisting infection from inoculations with bacilli of a higher degree of virulence. This power of resistance is needed to enable them to withstand the injection of the second and stronger vaccine, which, having been subjected to heat for only 12 days, is possessed of somewhat greater virulence.

In his early investigations Pasteur made experiments upon a flock of 50 sheep. Half of these were vaccinated with his weakest culture of anthrax bacilli. Twelve days later they received an inoculation with a stronger culture, and 40 days after this the whole flock was inoculated with a virulent anthrax culture. Two days later the vaccinated animals were all sound, while the checks, those not vaccinated, were all dead.

Following this striking demonstration by Pasteur, 60,000 sheep and 6,000 cattle were at once treated in France. The following year the same form of treatment was applied to 270,000 sheep and to 55,000 cattle. Since that time this method of vaccinating against anthrax has found very general application in France whenever losses occurred, and it was evident that certain fields or pastures had become infected with the disease germs. As a result, Nocard and Leclainche state that anthrax has disappeared from many sections in which it formerly decimated the livestock and that the medical authorities at the same time reported a disappearance of malignant pustule from among their human patients.

In the Pasteur method of vaccination there are, however, disadvantages which must be duly considered. To obtain satisfactory results from the use of Pasteur's vaccine it is of primary importance that the product be active. Experience has proved that this type of vaccine, if subjected to unfavorable conditions, may deteriorate within a short time after its preparation.

Then, too, it must be considered that vaccination by Pasteur's method requires two handlings of the animals; that the fullest degree of immunity is not obtained until possibly a week or 10 days after vaccination; that the losses from vaccination are not insignificant; and that the administration of the vaccine in herds where the disease has not yet made its appearance is liable to induce the disease through the reduction of the resistance of the animal during the development of immunity in the process of vaccination.

Other investigators, fearing to use the living anthrax bacillus, even though greatly attenuated, turned their attention to the production of a serum that should possess immunizing powers equal to those of the attenuated organism. The immunity provided by serum inoculations becomes effective very quickly, but does not last long unless reinforced by the addition of virulent material at about the time that the serum is injected.

SERUM VACCINE, SOBERNHEIM'S METHOD

Very interesting facts have been revealed through the efforts of various investigators to perfect serums for immunizing in outbreaks of anthrax. It is well known that a very small quantity of virulent blood will serve to convey the disease from an anthrax carcass to a healthy animal. A fly can easily carry enough on its proboscis to kill a horse. It may safely be admitted that a single drop is sufficient to cause the death of a horse; yet Sobernheim, of Berlin, by means of repeated injections, using cultures gradually increasing in virulence, has produced such a high degree of immunity in a horse that it withstood the injection into its veins of 500 cubic centimeters (about 17 fluid ounces, or more than a pint) of the most virulent anthrax culture obtainable. This is a good illustration of the meaning of "immunity." It is a power that the horse in question developed in his system through the many inoculations and that enabled him to receive unharmed an injection of living anthrax fully 10,000 times as large as the amount that would have sufficed to kill him before his immunization.

The method devised by Sobernheim possesses the advantage of requiring but a single handling, thereby avoiding the inconvenience of restraining the animals at different times for the administration of the Pasteur vaccines, and its effects are more quickly manifested than those of the double vaccination. The animals receive simultaneous injections of immune serum upon one side of the body and anthrax culture on the other side, the latter being very similar in virulence to Pasteur's second, or stronger, vaccine. Vaccination by this simultaneous method is usually followed by a slight elevation of temperature and diminished appetite. A swelling frequently develops at the point of the injections. In many instances the nasal membranes exhibit considerable swelling, and inflammatory eruptions of the skin are often observed.

The only criticism to be made of Sobernheim's method is that the type of vaccine used in conjunction with the serum, being similar to Pasteur's vaccine, does not possess any better keeping qualities. Thus, if an inert vaccine should be administered together with the serum, the duration of immunity would be no longer than that obtained if serum alone were injected.

BUREAU OF ANIMAL INDUSTRY SERUM AND SPORE VACCINE

The Bureau of Animal Industry has done considerable work with the view of perfecting a satisfactory method for vaccinating against anthrax.

Several horses were vaccinated against the disease and then hyperimmunized by first injecting them with very minute quantities of virulent anthrax culture (one two-hundredth of a loopful) and gradually increasing the quantity injected until they could withstand the injection of the growth from six to eight large mass cultures of the organism. These horses were then bled and on testing the serum it was found to be highly potent.

The next step was to prepare a reliable vaccine to be used simultaneously with the serum. For this purpose the bureau has prepared a spore vaccine that possesses far better keeping qualities than anthrax vaccine made after Pasteur's method. Furthermore, such a vaccine may be accurately standardized, since a definite number of spores can be placed in each dose. Numerous experiments and field tests have demonstrated that animals given an injection of serum on one side of the body, followed immediately with an injection of spore vaccine on the other side, were given an immunity from anthrax which persisted as long as that conferred by other methods of vaccination.

This method has several decided advantages over the other methods of vaccination against anthrax. The animal is rendered immune almost immediately following the vaccination; it need be handled but once; and the vaccine, being the spore form of the organism suspended in a saline solution, will remain potent for a long time and will resist conditions which would be detrimental to other forms of vaccine.

In using this method of immunization it has been found that 10 cubic centimeters of a potent serum injected subcutaneously on one side of the body, followed immediately with a subcutaneous injection of 1 cubic centimeter of spore vaccine on the other side, is sufficient to immunize a grown animal against the disease. In all forms of vaccination against anthrax in sheep the greatest care must be taken, since these animals are highly susceptible to the disease. It is therefore advisable to give a sheep 10 cubic centimeters of serum and only one-fourth of a cubic centimeter of the spore vaccine.

When vaccinating a herd of cattle against anthrax, if there is reason to believe the disease is present it is advisable to take the temperatures of the animals. Those showing elevated temperature should be separated from the others and given the serum alone in doses of from 30 to 100 cubic centimeters, depending on the severity of the infection. The others in the herd may then be given the simultaneous treatment. Animals given serum alone should be revaccinated after several weeks with both the serum and vaccine.

Recently a product known as anthrax aggressin has been developed for the immunization of animals against anthrax. This aggressin contains no germs and is, therefore, incapable of producing the disease in healthy animals. Sufficient data are not yet available to evaluate the potency of the aggressin as compared with that of the Pasteur and Sobernheim vaccines.

CARE IN HANDLING VACCINE

The bacterial vaccine used in immunizing from anthrax is not free from dangerous properties, since it contains living anthrax organisms; hence it should never be used except where the disease has already appeared, and only by qualified veterinarians, as improper handling may result in the serious extension of the very disease that it is desired to eradicate. Vaccines and serum for this work should be obtained from reliable manufacturers, as the use of weakened or diluted material can only lead to disappointing results.

The season of the year in which the vaccination is undertaken makes considerable difference in results, for it has been shown that there is a natural tendency toward the suppression of the disease in the infected regions during the winter months. Animals that are to be pastured in fields known to be infected with anthrax should be vaccinated about a month before being turned out. It is very important to protect recently-vaccinated animals from exposure to severe weather, as harmful results may follow any conditions which tend to lower their powers of resistance.

OTHER PREVENTIVE MEASURES

In future attempts to eradicate anthrax from infected districts preventive inoculation will undoubtedly play a very important part, but, in addition to the vaccination, there are other steps which should be taken into consideration. Infected areas should be thoroughly drained and kept under cultivation for some time before attempts are made to pasture stock upon them. Sunlight greatly hinders the development of anthrax bacilli, and the repeated stirring of the soil favors the action of the sun's rays.

The complete destruction of all anthrax carcasses is also a very important matter. This is best accomplished by burning, but as this is impracticable in many localities deep burial may be practiced instead. Covering the carcasses with quicklime when burying them adds another valuable precaution against dissemination of the infection. No animal dead from anthrax should ever be skinned or cut open, as the blood from such sources is one of the most dangerous means of spreading the infection, since it contains great numbers of bacilli which quickly turn into spores as soon as spread about upon the face of the ground. All discharges from the body openings should also be burned or buried deeply, as they are frequently of a virulent character.

DISPOSAL OF CARCASSES

One of the most common obstacles to sanitary control of outbreaks of anthrax is the opposition of the animals' owners to any regulation requiring them to dispose of the carcasses in a safe and satisfactory manner. Many localities have no legal enactments demanding suitable destruction of infectious carcasses. Not infrequently carcasses filled with deadly material are allowed to lie about in the fields, to be scattered by prowling dogs or by birds; or they may be dragged to the nearest stream and thrown into the water, in which case they are floated along, bearing their infection to neighboring properties.

It is imperative to burn or bury all carcasses of animals dead from anthrax if the eradication of the infection is ever to be effected.

While the majority of farmers recognize the advisability of burying the carcass promptly, there are some who allow it to lie and decompose or be eaten by dogs and buzzards. Parts of the carcass may be carried by dogs to adjoining or distant pastures, thus spreading the infection. Spores forming in the carcass opened in this way may be carried upon the feet of dogs or upon the feet or bills of buzzards and permanently infect pastures miles away. The soil upon which such an animal has lain would certainly be infected and remain so for many years.

During the last few years deep burial, rather than cremation, has been practiced with good results so far as can be ascertained. While cremation properly carried out is undoubtedly the safest method of disposing of an anthrax carcass, it is practically impossible to destroy absolutely all vestiges of the body and bacilli-laden body fluids, and unless this is done the whole operation so far as it goes is almost a useless waste of time, material, and labor. In the cremation of a carcass in the field even the earth upon which it has lain should be thoroughly and deeply burned over so that the heat will penetrate to a depth sufficient to kill the anthrax bacilli that certainly passed into the soil with the body fluids when rupture occurred from the heat. Enough is known of the biology of the anthrax bacillus to take advantage of the fact that if kept in the closed cavities and blood vessels of the body where no air can reach them, not only will the bacilli fail to produce the resistant spores but they will actually become noninfectious and die following the decomposition of the tissues around them.

U. S. GOVERNMENT PRINTING OFFICE: 1931

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - Price 5 cents